S. HRG. 103–363

SCIENCE, TECHNOLOGY, AND THE FEDERAL GOVERNMENT

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Science, Technology, and the Federa...

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

JUNE 22, 1993

Printed for the use of the Committee on Commerce, Science, and Transportation

DEPOSITED

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CONTENTS

	Page
Opening statement of Senator Burns	5
Prepared statement	6
Opening statement of Senator Hollings	3
Opening statement of Senator Rockefeller	1

LIST OF WITNESSES

Griffiths, Phillip A., Chair, Committee on Science, Engineering, and Public Policy, National Academy of Sciences, and Director, Institute for Advanced Study	7
Prepared statement	11
Press, Dr. Frank, President, National Academy of Sciences	3

SCIENCE, TECHNOLOGY, AND THE FEDERAL GOVERNMENT

TUESDAY, JUNE 22, 1993

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY,
AND SPACE OF THE COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 11:07 a.m. in room SDG–50, Dirksen Senate Office Building, Hon. John D. Rockefeller IV (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Patrick H. Windham, professional staff member; and Louis C. Whitsett, minority staff counsel.

OPENING STATEMENT OF SENATOR ROCKEFELLER

Senator ROCKEFELLER. Gentlemen, before I even give my opening statement, let me ask both of you, do you think there is phony, false, or real momentum toward adjustment on the part of the Federal Government in terms of technology, science, and technology? Are we all just talking, or do you see real changes?

[Pause.]

Dr. PRESS. Well, I have been in town long enough to see trends, and I have been wrong many times. However, I feel there is a readiness now for partnerships to develop between the Government and industry in certain key areas where that kind of cooperation might help those industries that are global in extent and are very important to the economic performance of the Nation.

I see that in Congress and I see that in the executive branch, and it has not started with this administration. You can see the trends beginning in the previous administration.

Senator ROCKEFELLER. I know it is at the top of this administration, but is not one of the lessons of bureaucracy that it has to go on down quite a bit farther?

Dr. PRESS. Before it really gets done; yes.

Senator ROCKEFELLER. Let me give you an example. I am really angry at the Clinton administration—I hope to clear this up today with Bob Rubin—simply because I am having trouble trying to get venture capital money that will relate to critical technologies. SBA does not do that. Commerce has been reluctant to get into that.

So, in other words, the administration is talking again about new technology, and critical technologies above all, and yet when it comes down to actually putting out, doing the financing, they really

held back, and I have discussed this a lot with them, and they continue to hold back.

So, we are probably going to have to make some kind of a compromise between SBA, which really has no business doing any of this at all, has no particular experience in technology, and cuts off aid to firms worth more than about $10 million? If you are worth more than $10 million you do not qualify, or $2 million, or something of that sort.

The Clinton administration has not done anything to get into this and be helpful, so I am going to talk this afternoon at Bob Rubin, and hopefully that will do it, but you see what I mean? In other words, the talk versus the action on the nitty-gritty.

I am not trying to be testy, Frank. I revere you, as you know. I am just trying to get you——

Dr. PRESS. Let me give you another perception. When I was in the Government, in the Carter administration, I tried to run something called the Cooperative Automobile Research Program. The name was CARP.

Its mission was to get the automobile companies working with national laboratories and universities, not on redesigning a new car, but on the more fundamental things of new materials and new electronic devices for cars. I called all of the executive vice presidents for R&D of these companies and asked them to come to my office in Washington to discuss this plan. They all refused to come on advice of attorney.

Senator ROCKEFELLER. Antitrust.

Dr. PRESS. Yes. But now they can do that today because of legislation in 1984. And, now we do have the Battery Consortium, which is, I believe, a very good program.

So, I understand what you are saying, but there are some hopeful signs. The NIST budget that the administration proposed has gone up severalfold, and that does have components of giving more companies access to technology.

Good luck in convincing the White House. I hope it comes out successfully.

Senator ROCKEFELLER. I cannot guarantee it will. I will pick at him. He will not go home until he says yes, or we will have to settle for a compromise as so often happens in Government, in order to go ahead on critical technologies, but you have got to get the best that you can.

Phil, I totally apologize to you. I now have a very short statement, and then, Frank, you go ahead and give your statement.

We want to look at the long term on the science and technology policy, not just where we have come from since the end of the cold war, but also looking out ahead, and there are several issues, I guess, that are on my mind that I would say to both of you.

I want to put these issues in the context of an era of budgets which are tight, and they really are—they really are. We know that intellectually, but when it gets down to fighting for things that we have been accustomed to fighting for, we do not stop. We somehow think that there is extra, and there is not any more. It really is an era of tight budgets, and in the meantime research is getting more expensive.

Should the United States, first question, try to be active in all areas of science, in all areas everywhere? Should we pick priorities instead, and if we do that, how do we pick the priorities?

Second, as economic competitiveness becomes more important, should Federal policy place a greater emphasis than in the past on engineering research, and more emphasis on supporting industry-led research projects?

Third, if science and technology priorities shift, what would be the respective roles of universities, Government laboratories, and corporate research? Then finally, in the biomedical area, can our research community create new treatments and technologies that save lives but at the same time are affordable, since technology is one of the giant hyperinflationmakers of health care?

Mr. Chairman, your comments, please.

OPENING STATEMENT OF SENATOR HOLLINGS

The CHAIRMAN. The Commerce Committee has long worked to set science and technology policies which meet our Nation's needs. For many years, national security was our most pressing concern. Now, with the cold war over and international economic competiton intensifying, jobs and industrial strength move to the forefront.

A new era requires new thinking and new priorities. The national academies have worked hard on these issues, and I commend them for the new report being discussed today. That report is an important step in rethinking the objectives and mechanisms of Federal science and technology policy, and I expect that it will have a wide influence on policymakers.

Today, I also want to commend Frank Press on the conclusion of his distinguished tenure as president of the National Academy of Sciences. As both NAS president and, earlier, as a renowned professor and then science advisor to President Carter, he exemplifies the highest standards of public service. He deserves our thanks.

Thank you, Mr. Chairman.

Senator ROCKEFELLER. Thank you, Mr. Chairman. Dr. Press.

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

Dr. PRESS. This is a special occasion for me Senator, because it marks the last day in my presidency of the National Academy of Sciences. My 12-year term is completed.

Senator ROCKEFELLER. And your colleagues gave you a big——

Dr. PRESS. A shindig, yes.

Senator ROCKEFELLER. We do, too. When I say "we," I am looking at all my colleagues here.

Dr. PRESS. I like the fact that I am here at your first hearing dealing with science policy in your capacity as the new Chair of this subcommittee. It is a special event for me, because I think this report that we have released and are going to tell you about may be one of the more important things that we have done over the years.

The report's origins are mixed. There has been much discussion across the country about appropriate Federal science and technology policies. The committees of Congress, the Office of Technology Assessment, reports of our own organization, universities,

study groups, et cetera—they are all exploring this issue because they recognize that the times have changed.

You mentioned that the cold war is over. But there is a new era of global economic competition and cooperation, and most nations view science and technology as their special advantage for economic success in the years ahead. Even the newly industrialized nations like Korea, Taiwan, China, which you know a lot about, and increasingly Brazil, are exploring their options and possibilities in the area of advanced technology.

If we as a nation do not maximize our great strength and build on our great strength in science and technology, we are losing something very valuable.

The academy's committee on science, engineering, and public policy, which is our highest level committee, undertook this. They have been working and talking about it for 1½ years, and have been actively involved for the last 6 months. We believe that our report is coming out at a good time. There is that readiness for the reasons that I have given.

Also, you might say that we have come to the end, perhaps, of 40 years of the Vannevar Bush era.

Senator ROCKEFELLER. Of the which?

Dr. PRESS. Of the Vannevar Bush era.

Senator ROCKEFELLER. OK.

Dr. PRESS. His report set the stage for the growth of science and technology 40 years ago. It led to the National Science Foundation, and to the enhanced Federal role in the support of basic science, but he was riding the wave of the momentum of the success of science and technology.

Senator ROCKEFELLER. Sort of like Flexner.

Dr. PRESS. It is what Flexner did for medicine. Right, perfect analogy. But that was a long time ago, and there are people who are skeptical about that era who are raising a lot of questions—why has not science done this, solved that problem, and so on—and so I think the timing is appropriate for us to renew this interest in what the appropriate Federal policy should be, and that is what we have done.

The present system for determining the appropriate level for the support of science, if not chaotic, is certainly not coordinated. There are always uncertainties—are we spending too much, are we spending too little—and there are also issues of allocation across different fields and priorities in science. We have always talked about them, but I think we have never really come up with a rational way or procedure for addressing these issues.

In addition, the issues of big science versus small science have always cropped up, diverting our attention from the lack of a process for exploring the Federal role in science and technology. What we are proposing here is an outline for this Government role. We recommend that the Nation establish goals for itself and justify them, that there be a yardstick and we describe that yardstick, for measuring whether or not we have met those goals.

From this, one can determine the funding levels that would be appropriate overall for science, and for each of the major fields of science. In the report we are not asking for more money or for less money. We are proposing a process for reaching that conclusion,

and that is what is special in the way that we have attacked this issue.

Technology is another matter, because unlike science the Federal Government is not the main player in technology. That role has to rest with American industry. Therefore, we have a separate chapter dealing with an appropriate technology program for the Government.

Let me stop here, and then I will participate in the question period, because I want the Chair of our panel to tell you what the panel has come up with and to summarize their conclusions.

Senator ROCKEFELLER. Frank, you can do that, and I want to call on Senator Burns, but I must say that your service has been extraordinary, and if this really is the last day, it is kind of wistful; is it not?

Dr. PRESS. I think so.

Senator ROCKEFELLER. Yes. Yes, because you served during times when it has been hard to get the attention of the public in general, and the public sector in particular, on the things that you care about the most.

In a sense, the budget worked against you, and in some sense ideology worked against you, although interestingly, there is no guarantee that that will be easier now either. But on the other hand, because of what you did, you created this underlay of information, and a wellspring, so to speak, of pent-up desire to create closer collaboration in terms of science and technology and Government research.

So, if you have any days when you look back when you think about what you would like to have accomplished, you probably have laid the ground for what will be accomplished, so let me just say that.

Senator Burns, unless you wanted to say something——

OPENING STATEMENT OF SENATOR BURNS

Senator BURNS. No. I have just got a statement we will put in the record.

Senator ROCKEFELLER. Well, what if I refuse to do it and make you read it?

Senator BURNS. I will go back to the office.

Senator ROCKEFELLER. He will go back to the office.

Senator BURNS. I just want to say, Mr. Chairman, thank you for holding this hearing, and Dr. Press and Dr. Griffiths for coming today. We appreciate that very much.

It seems like we have a sort of a misconception in this country that because we do not—we are not in the headlines with sexy issues that sometimes the work that you folks do and this Government does in this area sort of goes unnoticed, but we know that it is sort of like that duck on the water. On top of the water, you look very calm and collected, but underneath the water, you are just peddling like the dickens.

So, I appreciate your work in identifying some goals which we have to attain. We have not in this area been all that successful in generating a lot of enthusiasm for the disciplines in scientific research, especially from the Government down.

We have to find out some way that this has to start from the grassroots, and we should set the policy or the means in which to guide it, because understanding that we have got a position where we hope we know what the national needs are, and the goals and where we would like to be in order to guide that is an important first step.

So, sometimes I think our efforts are too much from here down, rather than from here up, and we just sort of steer it a little bit, but nonetheless, it is a very, very difficult job in the scientific community, and there are not too many scientists or those in those disciplines that make very good salesmen. That is up to us as unscientific people to do that, and we want to help you in those endeavors.

I thank the chairman, and I will just submit my statement for the record.

[The prepared statement of Senator Burns follows:]

PREPARED STATEMENT OF SENATOR BURNS

Mr. Chairman, thank you for holding this hearing on the new National Academy of Sciences Report on Federal Science and Technology Policy. This is an important document. It suggests a thoughtful framework for allocating our $70 billion Federal R&D budget in a way that will address national issues like health care, environmental protection, and U.S. competitiveness.

Increasingly, the solutions to various problems facing our Nation seem to lie in science and technology. For example, advances in telemedicine promise to expand access for rural citizens to regional medical centers through teleconferencing. Similarly, in biotechnology, scientists are working on new strains of crops that are more resistant to frost, and special fungus that will kill weeds without harming crops. Finally, the Federal effort to develop a national data communications network combining telephone, cable, computer, and entertainment technologies has the potential to produce revolutionary breakthroughs in research, education, and business.

It would be nice to fund every scientific research project. However, we are in a tough fiscal environment where we have to make some difficult choices among many deserving areas of research. I think the report provides some useful advice on how the Federal Government should make those choices. Few can argue with the report's recommendation that our R&D budget be spent in ways that support U.S. leadership in key scientific fields and technologies. It is also beyond debate that a coordinated science and technology policy is preferable to the current piecemeal approach where each agency separately develops its R&D budget based on narrow agency goals.

I think that the Federal Government already seems to be moving in the directions suggested by the report. For instance, at least four separate agencies generate "critical technologies" lists indicating which fields are most important to U.S. competitiveness, national security, and other strategic goals. In addition, new multiagency initiatives in areas like global change and computing have been developed which stress focused R&D investment here and I am looking forward to hearing from our distinguished panel about its specific suggestions on how to cost-effectively implement the broad recommendations contained in the report.

Thank you, Mr. Chairman.

Senator ROCKEFELLER. And one of the good things, Senator, in this area, with this new subcommittee arrangement with the two of us from our respective parties, there is a lot of cooperation, and frankly, that is worth a lot. If you start off with a good relationship in a subcommittee, you get so much done. If you do not, it is hard to get anything done.

So, with that, Phil, why do you not go ahead?

STATEMENT OF PHILLIP A. GRIFFITHS, CHAIR, COMMITTEE ON SCIENCE, ENGINEERING, AND PUBLIC POLICY, NATIONAL ACADEMY OF SCIENCES; AND DIRECTOR, INSTITUTE FOR ADVANCED STUDY

Dr. GRIFFITHS. Thank you, Senator Rockefeller and Senator Burns, for the opportunity to come today and speak briefly on behalf of this report. What I would like to do in this presentation is make two main points, I think, which focus on two of the salient issues on the report, and then turn to questions and comments that you may have.

The first main point I would like to speak about is the research and development system, the role of science and technology within that system, and the Federal role in science and technology. The second point is the statement of goals for national performance in science, and for the Federal role in technology development and adoption.

Let me speak just briefly, then, about the first of these, the research and development system. The research and development system is just that, a system. It is unitary, it is complex, and it is varied. As in any system, the different components must all be in place and functioning effectively in order for the system as a whole to be effective. The components of the research and development system, or science and technology within that system, include basic research, applied research, technology development, technology adoption, and throughout all of these, the development of human resources, of trained personnel, skilled scientists and engineers, and so forth. That makes the system work.

All of these components must be in place and all must be strong and they all must be interacting properly in order for the system as a whole to be functioning. I emphasize this because I think that over the years there arose some views of the research and development system that captured only a part of it, and we need to understand the whole system in its complexity in order to see what policies we should have in place for science and for technology.

For example, there was the so-called linear model of development, which held that you first began with basic research, then you turn to applied research, then you had development, and then you had production. And the Federal role was in basic research, and once that was in place, everything else would follow.

I think that model does apply in certain sectors. For example, biotechnology works at the moment that way. But by and large, it does not apply in microelectronics, it does not apply in mature industries such as automobiles. The system is much more complex. It involves feedbacks from the applied research from development into basic science, and it is an interactive system, where one has to analyze the different components of it to appreciate the variety and complexity of it.

I say that because understanding the system as a whole provides the answers to questions that people have been asking in recent years, such as how is it that we can be ahead in many areas of basic science and research, winning all these Nobel prizes, yet we are losing technology- based industries. The answer to that lies in the understanding of the research and development system as a

whole, and how all the pieces of it must be in place and interacting in order for the system as a whole to function.

The question which was discussed last year was about whether basic sciences should redirect their effort in order to address more immediate societal objectives, like economic competitiveness, environmental issues, heath care costs, things like that; again, the answer to that question lies in understanding the concept of the research and development system as a system.

I think the four questions that you posed at the beginning of this hearing, at least three of the four, may be understood in the context of that system, and I will come back to those, if you like, at the end.

So, one of the things that we have tried to do in this report was to set the current context for science and technology within the overall research and development enterprise, and by illustrations of concrete examples to portray this system as a unitary system in which there are these various components that must all be in place. Given this, one can go on to develop goals for the Federal role in science and technology.

Let me speak first to the Federal role and to the goals that we propose in science. I think that the strength in scientific research is an essential part of this system. It does not guarantee that the system as a whole works, but it must be working in order than the system can work.

Beyond that, I think that science-based technologies will be major sources of new industries and new jobs. The strength that we as a nation have in scientific research forms the wellspring for those future science-based technologies, and therefore forms the capital that we as a nation have that must be used and must be maintained in order for us to maintain and strengthen our economic position, to address the environmental issues, to address health care issues, to address national security issues.

All of those areas where science and technology will be an essential contributor to the Nation's welfare ultimately depend on our strength in basic research, among other things. And they must all be in place and interacting for the system as a whole to work.

Given this, I think we may ask the question how should we, as a nation, be positioned in science? And here, we propose two performance goals. The first is that we should be among the leaders in all the major areas of science. Now, this goal, when first stated, sounds in a certain way as something that is almost self-evident. But let me speak about it just for a moment to try to illustrate what is behind it.

I think first, it does not say that we should be ahead of everyone else in all areas of science. On the other hand, it does not say what the report from the United Kingdom, that came out just a few days ago addressing the role of their government in science and technology, says; namely, that they, because of the size of the country and other factors, do not feel that they can afford to be at the forefront in all major areas of science. So, they will have to choose some.

So, what we are saying is that we should be among the leaders in all the major areas of science. This is the first goal that we propose.

Senator ROCKEFELLER. Do you make a difference there, and Senator Burns, please forgive me, and both of you please forgive me as I interrupt, can we do that?

Senator BURNS. Go ahead.

Senator ROCKEFELLER. Do we assume that England's budget constraints are radically different from our own? You were clearly setting them up as one case and us as a second. And the implication was about to be that we do not have those constraints.

Dr. GRIFFITHS. It is a smaller country. I cannot speak knowledgeably about what their budget constraints are, other than those of proportionality.

Senator ROCKEFELLER. OK.

Dr. GRIFFITHS. I think, on the other hand, one could look at the European Community as a whole. I do not think they yet have a policy for scientific research across the community. But it is certainly the case that they, taken as a community, are strong in all the major areas of science that I am aware of.

Dr. PRESS. I think it is the plan of the European Community in concert to be very strong across all fields but perhaps share the burden among individual countries, and per this white paper that was released in England did discuss in detail the connection between the United Kingdom and the European Community in the years ahead, and the United States, as well.

Dr. GRIFFITHS. There are a number of rationales for this goal, and I would like to single out two. I think the first is that it is only by being at the forefront in all of the major areas of science are we in the position to take advantage of breakthroughs, of opportunities that occur when something is discovered, no matter where it is discovered.

So, for example, when new high-temperature superconducting materials were discovered in Switzerland some years ago, within 24 hours those experiments had been reproduced in a number of laboratories in this country. What that means is that in the development of technologies based on high-temperature superconducting materials, as far as the science that was needed for this technology, we were not at a disadvantage.

There are many other examples of this kind. We do not know, and no one can predict with any degree of certainty, where there will be breakthroughs in science that will lead to major technologies which will lead to new industries, and it is only by being in the forefront in all the major areas that you are in a position to take advantage of these breakthroughs, wherever they may occur, here or elsewhere.

I think another rationale is in the training of scientists and engineers. Only by working at the forefront in the major areas of science can we be assured that in training personnel to go to work in industry they will receive the training that is of the quality of that that is going to be received by trained scientists and engineers elsewhere. There are a number of other rationales for this first goal, but I would single out those two, I think, being especially appropriate.

The second goal that we propose is that there are certain areas in science that we as a nation should be in a position or at least strive to be in a position of clear leadership, because there is an

overwhelming national interest that we do so. There will be certain national objectives—be they in health care, be they economic competitiveness issues, be they national security issues—where we want to be ahead of other countries because we want to be in a position to take advantage of that store of scientific knowledge to put it to a use that will benefit the society.

For example, microbiology is at the basis of the biotechnology industry. It is also at the basis of many of the breakthroughs that are occurring in health care, development of new drugs, and so on. This is an area that I would suggest is worthy of consideration for leadership on the part of this country in its research.

In the report, we suggest several criteria. These are criteria that are external to the fields in question, and generally, they are based on issues that involve national societal goals.

How might one go about implementing these two recommendations? How do we know where we stand in a field of science? Are we competitive in physics? Are we competitive in astronomy? The report goes in some detail about how one may convene assessment panels. These would be panels of scientists in the field so they know—they are the ones who are in the best position to know—how we stand.

The scientists should be both from this country and from abroad, so that we get both international as well as an internal perspective, and the panels should contain experts who are knowledgeable in the field but who are outside of the field so they can bring the external perspective to the consideration.

These sorts of assessments have not been done in the past. In my mind and the minds of the people on the committee, there is no doubt they could be carried out. You could not carry them out with infinite precision, but you can say with certainty, I think, whether we are among the leaders in an area of science.

But there are trends in the support of science. For example, in developing infrastructure, facilities, and instrumentation, or in human resources, who is coming into the field that cause concern for where we will be positioned 5 or 10 years from now? So, I think in discussing this goal, one not only speaks to where we are, but looks out at the future, as to where we will be.

These are the two goals, then, that we propose. In the opinion of the committee we are currently well positioned with respect to these goals. I think in most areas of science we are certainly among the leaders, and in many areas we are in a clear leadership position.

The committee did not feel that major budgetary reallocations within the overall research and development budget were necessary at the current time. Some adjustments may be necessary, but more tuning than major adjustments. On the other hand, over the long term I think we do need to worry about issues such as personnel, and such as infrastructure, to make sure that we do maintain our position and are able to, with some confidence, say that these goals will be met with in the future.

Turning to the Federal role in technology, this is a subject that has been discussed quite a bit in recent years. I think that the Federal role in technology is an evolving one, and the committee suggested that there was an appropriate Federal role. But in contrast

to the goals for science, the enabling of technology was not something that could be predominantly accomplished by the Federal Government.

I think it needs the involvement of the private sector, and it is only through partnerships and private sector participation, through choosing technologies on the basis of the willingness of corporations to participate in the effort, market forces, and things of that kind, that we will be able to have an effective technology policy.

The way the committee thought about it was that the Federal role should be an enabling one, a catalytic one, and that the national objective should be that in major industries that are of importance to this country we should not lose our competitive position on the basis of technological backwardness.

So, whenever a policy is in place, it should ensure that this is not the reason that we lose out somewhere. And if you formulate it this way, then there are a number of guidelines, some of which I suggested that are in the report for how this may be carried out. We did not go into detail exactly what this policy should be, nor the implementation mechanisms, but rather strove to formulate it together with suggested guidelines which might serve to be a useful component in the current discussion.

In the beginning of my statement I spoke about the research and development system as a system. I spoke briefly about the role of science and the role of technology development and adoption. An extremely important component of this system is that of human resources; scientific personnel, both advanced and baccalaureate, as well as the general workforce—the need for a skilled and adaptable workforce. I think that this is a component of the overall system that is clearly of importance.

The system obviously will not work unless this is in place. The committee did not get into an analysis of what our goals might be here, especially with regard to advanced training, things of that kind. That is a topic that I hope the academy will return to. I wanted to mention it because I think we certainly considered it of equal importance. But we limited our discussion to the Federal role in science and technology for the purposes of this report.

Thank you.

[The prepared statement of Dr. Griffiths follows:]

PREPARED STATEMENT OF DR. PHILLIP A. GRIFFITHS

The premises that have driven the federal government's policies toward science and technology for nearly half a century are changing. For much of that period, these policies have been shapea by the demands of the Cold War and by the country's eeonomic supremacy. Today the Cold War is over and U.S. economic leadership is being challenged. As a result, the science and technology enterprise has been undergoing its most thorough reexamination since the end of World War II.

A substantially altered rationale for federal support of science and technology is now emerging. It is based on the growing interdependence between science and technology and broad national objectives in such areas as industrial performance, health care, environmental protection, and military security. The Committee on Science, Technology, and Public Policy, which I chair, has come to the conclusion that to take full advantage of this interdependence, this nation should adopt specific national goals for science and technology. New knowledge and new technologies generated by the science and technology enterprise-will continue to contribute to national objectives. And the scientific and engineering communities will benefit from the predictability made possible by overarching goals.

NATIONAL GOALS FOR SCIENCE

Science-driven technologies are continuing to transform the ways people move, communicate, do business, and conduct their lives. But science and technology are rarely sufficient by themselves to bring about human progress, and in some cases they are clearly insufficient. The central question therefore becomes: What role should science and technology play in the broader social and institutional systems of which they are parts?

Our committee came to the conclusion that the proper role for science and technology can be summarized in the form of national goals. First, we have recommended that the United States be among the world leaders in all inajor areas of science. Remaining at the forefront of science enables the TJnited States to absorb and benefit from new advances, regardless of whether they occur here or in another country. For example, high-temperature superconductivity was discovered in Switzerland, but U.S. researchers were able quickly to repeat and extend those findings, giving this country an immediate presence in a promising new field.

In our report, we have recommended that panels of experts from within and outside scientific fields be established to compare the performance of U.S. researchers with that of researchers in other countries. These panels could suggest ways to address areas of weakness and to allocate funds in accordance with the goal of remaining at world frontiers.

Our second goal for science is that the United States should seek to maintain clear dominance in those scientific fields likely to contribute substantially to important economic, social, or cultural objectives. In this way, decisions to select a research field for leadership would be based on criteria external to the field.

Because the United States is already among the world leaders in most areas of science, and because of ongoing adjustments within the federal R&D budget, we believe that the federal government can achieve these goals for science, at least in the short term, without major adjustments in overall &dditional spending on research and development.

GOALS FOR TECHNOLOGY

In the area of technology, our committee has recommended that the federal government cooperate with the private sector to maintain U.S. leadership in technologies that promise to have major impacts on industrial and economic performance. These technologies should be in areas that could lead to major new industries, as well as in areas in which U.S. firms have demonstrated their ability to convert technology into marketable products. This goal is designed to ensure that the United States not allow technological backwardness to be the decisive factor in the loss or failure of important industries.

By observing several basic principles, such as the need for costsharing, insulation from distributional politics, and stable support, the federal government could more actively promote the development and adoption of technology while preserving the vital role of the private sector in the marketplace.

IMPLICATIONS OF THE GOALS

Adopting national goals for science and technology would help shift the debate away from absolute levels of resources toward the ability of science and technology to support broad national objectives. It would provide a framework for assessing the performance of scientific fields, and in doing so it would provide a way of evaluating the levels of support for individual fields and for all of science.

National goals for science and technology would help resolve a number of other issues. They would offer a coherent method of balancing the different components of a scientific field, including individual investigators, acilities, and large projects. They would emphasize the importance of -Aeveioping the nation's human resources, since the goals outlined in the report can be achieved only by investing in the education of not only future scientists and engineers but the broader public that will support and make use of science and technology.

Science and technology will be essential in creating the new knowledge and wealth that America will need to remain a world leader in the twenty-first century. National goals will ensure that science and technology are able to meet the challenges of a changing world.

I would be happy to answer any of your questions.

Senator ROCKEFELLER. Thank you. Let me just start out with a question to both of you which picks up directly from where you ended, Dr. Griffiths. And let me wander into this question.

I have a first cousin who is an actress, and fortunately, she is not poor. And for her sake it really is fortunate because there is no work. There are, I think, only 19 plays playing on Broadway.

I, myself, have an enormous interest in classical music, but only between 4 and 5 percent of all CD's sold are classical music. And as a result, Julliard School and others are having an enormous problem in the placement of people, which then at some point is going to have an effect on those who choose to be or who want to go to Julliard.

Maybe music is different. I was at my daughter's graduation at Stanford, on the other hand, 2 weeks ago, and when the engineering class stood it was virtually one-half the entire graduate and undergraduate assembly. I am exaggerating a little bit, but obviously, Stanford is enormous in engineering. Hence my question.

I have always gone on the assumption that if you want to go into science and technology, that it starts working in your gut one way or another when you are 11, 12, or 13 years old, and it often has to be because of a model of a father or other role model, and therefore what is the treatment, the salary level, the position level of engineers, scientists, and others in the corporate world and how do we value financially, and otherwise, scientists, engineers. Today there seems a substantial emphasis, perhaps, on science, technology, and engineering for young people because the careers, both in terms of how many of them there are—corporations downsizing, Government not exactly expanding and hence the career that comes after that in science and technology and engineering, is more risky.

Now, I will end my question by giving what I think is something of an analogy. In health care, 10 years ago, if a child was born at 23 weeks, the child would be wrapped in a blanket and given to the mother and there would be a quiet understanding that the child was not going to make it because the child's lungs were not developed, et cetera, and the child would die and it was a covenant of sadness between doctor, hospital, and parent. Now, because of technology, we can keep those babies alive.

Now, what is alive?

Many of them will leave neonatal intensive care units 3 to 4 months later, brain damaged and physically impaired, but alive. On the other hand, just as the response of future musicians is going to be diminished by the underfunding of orchestras and chamber music, et cetera, and the rest of it, neonatal intensive care units are going crazy. I mean, they are an enormous growth industry and, as a result, six times as many neonatal physicians and nurses are now picking out that area to go into. And it may be an area which is in some ways an opposite to what will be our final judgments as a society on health care when we get down to really thinking about this.

My question is: What is the state of morale now for young people looking at a future in science, engineering, and technology as it might affect their career choices? Either of you?

Dr. PRESS. Not very good. We have not solved the problem of cycles in our economy, where we go through recessions and affluent times and scientists and engineers are let go and then are rehired. What happens is what is happening now in the present recession,

there are unemployed postdoctoral physicists looking for positions. The morale is terrible.

There are unemployed geologists because of the cutbacks in the oil industry. The young people see this, and they switch to other fields. You see enrollments at both the undergraduate and graduate levels dropping. Furthermore, there are fewer and fewer technically trained people coming out of the schools. Then we have a recovery. We always have had recoveries and we will have a recovery. There will be a restructuring of industry and a different form of industrial growth in this country. But the demand will be there in the years ahead for scientists and engineers, and they will not be available because of the memory of the recession.

Senator ROCKEFELLER. They work against each other?

Dr. PRESS. They are out of phase. The production of the universities is out of phase with the needs of the industry. And that is terribly wasteful. In the past, we have been lucky, because trained immigrants coming into the country smoothed that ripple effect and helped us along. But I think we have to think about this problem and what we might do about it.

Senator ROCKEFELLER. Do you have any comment on that?

Dr. GRIFFITHS. Yes. I would concur with what Frank said. I think the morale of the scientific community, as far as the science that is going on, is quite good. It is an extraordinary time in science. But, as far as the circumstances under which they are having to do their science, both finding jobs, the amount of time that is devoted to securing the funding, the issue of adequate facilities and instrumentation, I think those are all not working well.

One of the things that was certainly on the mind of the committee when we developed these recommendations was to try to bring some predictability and stability into the system of support for scientific research so that a scientist thinking about a career would be able to have some greater feeling of or some greater picture of what to expect than is the case now.

If, for example, in my field of mathematics we knew that we as a country should support a certain number of mathematicians in order to remain at the forefront, which we more or less are I believe, but in order to remain at the forefront, then you would have an idea that over the long haul there would be this many researchers whose work would be funded, and you would have some sense of what to expect.

If we knew that we were going to be able to renew our facilities and keep up to date in instrumentation, which would be necessary for us to remain at the forefront in the major areas of science, this would be of less concern. So that was certainly very much on the committee's mind. And if we had some explicit performance goals such as these, there would be, we hope, some predictability and some stability that would make scientific careers more attractive for young people.

Senator ROCKEFELLER. Let me ask another question and then I will turn to Senator Burns.

Let me give this to you, Dr. Griffiths. This relates to critical technologies, and whether or not we are trying to stay ahead in this area. You said in your report that the Federal Government should adopt the goal of maintaining a leadership position in those tech-

nologies that promise to have a major and continuing impact on broad areas of industrial and economic performance.

Now, what exactly do you believe that the United States can and should do to maintain leadership in key technologies? How do we achieve leadership?

For example, should Congress place a greater emphasis on supporting industry-led research projects? Is that the path to technological leadership? Should companies help Federal agencies identify key areas of research and then evaluate or value the current research that universities and governments are carrying out?

What are some paths for us?

Dr. GRIFFITHS. The report goes into some detail about criteria for deciding which technologies there should be a Federal role in, and what that should be.

I think one of the major emphases is that—well, one of the first points is that in contrast to the science goal, the report does not say that we should be among the leaders in all areas of technology. It says that this is a selective goal. And there I would draw a contrast with science in that in science—a major area of science—you cannot predict whether it may become of importance in some issue of immediate societal relevance, such as economic or environmental. Whereas with the technology, since it is closer to utility—in fact, that is almost the definition of what "technology" is—you will have a much better sense of how useful this is going to be for societal purposes, and therefore, whether it merits support.

We also emphasized that the push, if you like, in the system, should come from the private sector, not from the Federal Government. The Federal Government should play a catalytic role, as opposed to an initiation role. And we listed some criteria for deciding whether there should be Federal participation with the private sector in an area of technology. And these are ones that I think you are familiar with.

Senator ROCKEFELLER. Bring something to mind, as you say, there?

Dr. GRIFFITHS. Well, the Battery Consortium is an example of something that is going on now. I think the jury is out, but it is certainly very promising.

There is another criterion which dealt with national security interests, which I think was certainly one of the considerations in Sematech, that we wanted to have domestic capability in microelectronics.

Senator ROCKEFELLER. We have, do we not, about 100 consortia around the country?

Dr. PRESS. What kind? If you talk about major consortia——

Senator ROCKEFELLER. Not necessarily major, but some degrees of cooperation between the Federal Government and the private sector.

Dr. PRESS. Yes, by now there are, I would say, perhaps, hundreds of cooperative research and development agreements between the national laboratories and industry. In addition, the research universities have programs with industry.

I can think of the program in high-temperature superconductivity between Bell Laboratory, AT&T, and MIT, for example. There are lots of these going on. The MIT participation

is primarily through the support of Government research at the university, and the industry puts in a certain sum of money. There are a large number of these programs. But, of the megaprojects in the $100 million range, like the Battery Consortium or the Sematech, I think there is only a handful.

Senator ROCKEFELLER. OK.

Senator Burns.

Senator BURNS. Thank you, Mr. Chairman.

Dr. Press, you mentioned the fact that morale is kind of low. And you mentioned geology. Did you read the Wall Street Journal Friday?

Dr. PRESS. No, I did not.

Senator BURNS. They had quite an article in there about mining and where our investments are going, and they are not being made in this country. Latin America is opening the door for major mining industries to provide jobs and some national economics down there and that the policies set in this country are forcing some of our industries out of this country, policies set by this Government.

And I was disheartened to see that an agency in this country, of this Government, had spent $67,000 in South America trying to write an environmental law that would shut down mining in Chile. They were not successful in doing so, because they passed another law that would allow them to do that.

I think whenever we start talking about scientists, educating scientists, that this is a double-bitted ax. There are also some policies over here that prevent us from really going into the area of doing something better, environmentally better with our metals. And I bring that up because in my State, what would we do in the area of environmental science if we did not have platinum or palladium and all those trace minerals?

There is only one mine in America, and that is in Montana. And yet, we are having troubles keeping it open because there are people who want to shut that down. It can only be found in Russia and South Africa.

So, with that, I think we have to be aware of what we do. Do we want those industries in this country? Are we going to educate our scientists and then send them somewhere else to put their knowledge and their research into practice somewhere else other than the United States? I think we have to look at that end of it.

Saying that, how can the United States do a better job in commercializing their inventions and their discoveries? Are there lessons to be learned from our foreign competitors in this regard?

Would you want to take a shot at that?

Dr. PRESS. Well, that is a tall question and a very important one. We touch on it in the report. We have not succeeded in the past at fully using the technology that we have developed in this country. That is a complicated issue, because there are so many factors involved in the adoption of technology and the creation of successful commercial products. It has to do with management's attitude, their ability to recognize new developments and make use of that.

What kind of managers have our business schools been turning out? That is a legitimate question to ask.

I think the cost of capital is important. The science is cheap compared to the technology development. That is where the big money

goes, where you take an idea and transform it into a product. The development of the idea is one thing. However, the development of a product may be 10 or 20 times more expensive. So that requires an investment. It requires capital and the cost of capital is a factor.

Of course, the cost of capital is a part of the macroeconomic policies of the Nation, and there are many, many issues there.

Then we have to develop quality products with a trained workforce.

If we do not have an educated, trained, skilled workforce, we may have the best advanced products that do not work as well as our competitors' products. So, education is a factor.

Finally, we have never, as a nation, looked at this in an aggregate fashion, taking all of these factors into account so that we can perform better. That is what we have to do.

Senator BURNS. Dr. Griffiths.

Dr. GRIFFITHS. I do not have much to add.

My opening remarks about the research and development system as a system, in which all the different components needs to be in place and interacting, that speaks to this issue. And I think that Frank outlined very well some of the components that need to be in place in order that we take advantage, really, of the scientific knowledge that we do have in this country. It is something we need to do a better job at.

So, the system as a whole certainly needs improvement. Science, in and of itself, cannot make it work. But it is necessary for it to work.

Senator BURNS. I would suggest in that area, where I know our energy labs, research done in alternative fuels, and into any field that you want to go into, we have research and products and information on the shelf that has never made it into the commercialization stage. I would say that maybe as much emphasis from your different organizations, the National Academy of Sciences and the Engineering Committee, maybe that committee or those people should place as much emphasis not only setting the goals for scientific studies and development, but also to study the bridge that gets those products into the commercial work.

And I am saying I look at Japan, where, of course, principally Japan has got a different system. Their government is business. Their business is government. They are so intertwined. Of course, that is the reason they have all those problems, too, that surface a little bit.

But I would suggest that we should look at that bridge. How do we bridge that? And place as much emphasis there as we do on setting the goals of our R&D as we work and we coordinate these plans. And if there is a way, I wish you would come back and say: How can we help you do that? How can we as policymakers help you do that? Make recommendations to us.

As far as reeducating our workforce, now, the chairman does not know it yet, but he is going to be approached on some legislation that I am crafting now, and he is going to be a part of it, we hope. I will spring it on him right now. But we think we have to reeducate our workforce differently. We may have to use new technologies to get them to participate and want to learn new skills—

or career changes and this type of thing. And I am working on legislation there.

But what we are looking for from I think your organization is: tell us how we can make that bridge for you. Because once we get that new technology into commercialization, do you realize that that also opens up terrific opportunities for our engineers and our scientists to move not into Government jobs, but into the private sector and take it and go from there?

You said the morale is a little low in that area, and I do not think we have made that bridge, and we need to work on that. And I am making a statement more than a question. But I guess what I am asking of you, help advise us on what we can do as policymakers to help you build that bridge if we can.

Of course, you get—well, no, I better not say that, because I get in all kinds of trouble.

Thank you, Mr. Chairman. That is all I have.

Senator ROCKEFELLER. Let me come back to either of you, but specifically, Dr. Griffiths, to you. Federal spending on science and research is only one factor, as we have discussed, of what is going to keep us among world leaders. Nevertheless, it is a big one.

Help me understand how your system would facilitate our determination of appropriate budget levels. Now, let me explain. Assume the current budget levels that we now have, and that in that condition we are among the world leaders in all areas of science, which is what you advocate. But then the French make major advances in botany, the Germans make enormous advances in chemistry, the Japanese zoom ahead in astronomy, et cetera. The United States is now not in a position of leadership in those major areas of science.

Then go back to the relatively fixed Federal budget level—in space and many other areas. The Clinton administration faces level funding for the next 5 years. And, indeed, it is more likely that there will be declines because only 15 percent of the budget is discretionary, and you know the competition very well for that money.

What does your system, Dr. Griffiths, suggest that we do about reallocating the Federal budget for science and research given that new scenario?

Dr. GRIFFITHS. The statement of the goal is that we should be among the leaders. And it may well be that in some particular area of science the French, as they do for example in certain areas of mathematics, have chosen—they have great talent and they put great emphasis in that area. Nonetheless, this country still remains knowledgeable about what is going on in those areas of mathematics even though the French are ahead, and I think we should remain knowledgeable. That requires somewhat less investment than to remain in the absolute leadership position.

So, I think the question that you are posing as an abstract question makes sense. But in the way that science functions, it will not be so difficult. And, you know, in the actual functioning of science, given the way it is international in nature now, that the community of botanists is really an international community. A botanist in a university is probably on more familiar terms with botanists in France than he is with historians in his university.

So, I think the reality is that this country has the resources and is currently well positioned enough so that these are realistic goals even, granted, that we are facing a period of fiscal constraint. I think it is really in the national interest that this aspect of the research and development system be maintained in its strength because only by doing that can we assure that the system as a whole can be made as strong as we want it. That really is the message of the report.

Senator ROCKEFELLER. Now, that is assuming then that nongovernment spending can adjust sufficiently to keep us at levels that keep us "among the leaders in the world no matter what." The flexibility is there.

Dr. PRESS. I think Phil mentioned this before. Because of the investment of the past 40 years, we are among the leaders in just about every field of science and preeminent in several. It is not that a big influx of funding is necessary at this time to implement our report.

The problem in the past has been that this has not been planned this way. We just threw a lot of money into many different areas, and that was the outcome. I think it was a fairly good investment. But because of the reasons that you gave of finite resources we need a better procedure at this time, and this is the procedure that we are outlining.

We want to maintain a position of being at the forefront, as good as most advanced countries. And then, based upon contributions to the economy, to the health of our people, to the environment, certain fields, based upon intellectual content, will be selected where we should endeavor to be clear leaders, and they will receive these extra funds. We have outlined a process about how you make these evaluations. Once you have these evaluations you will know how many more scientists or how many fewer scientists will be needed; how many more telescopes or fewer telescopes we would need, et cetera.

We feel that this is fine tuning of a relatively small sum in the Federal Government, and if the Clinton administration really is serious about reducing the defense program and transferring dollar for dollar in defense R&D reductions to the civilian R&D sector, there is more than enough money to do that.

In other words, we are talking about fine tuning and fine adjustments—a process that everybody understands and that makes sense to everybody.

Senator ROCKEFELLER. I understand. Again, Phillip, on page 32 you recommend that "the government should now take a more forceful approach for the development and adoption of technology than it has in the past."

Again, given that the Federal budget for research and development is not likely to increase for at least a period of time, and much more likely in fact to be reduced at least for a period of time as overall Federal spending is reduced, does implementing the recommendations mean that we will be forced to shift money from research into development?

Dr. GRIFFITHS. I do not know the answer to that question. The committee, when we deliberated about the revenue implications for the science goal—because this is something that is more within the

purview of Federal support as opposed to partnership with the private sector—this was something that we had a better sense of and we could estimate.

As far as what are the revenue implications of the technology goal beyond what is in the system, the $70 plus million, much of which is now devoted toward military purposes that may no longer be, to the particular degree that they have in the past, quite as necessary. To the extent to which those funds would enable one to meet this technology goal while maintaining the science base, it was something that we did not know the answer to, but it was something that we did not automatically say, yes, we need more money.

Senator ROCKEFELLER. Your report also says "assessment of research performance would also help resolve debates over the support of megaprojects." Guess what is coming. "The cost of megaprojects would be assessed in terms of the performance goals." Now, that is what you say. Now, you know perfectly well that we have an enormous set of fights coming.

Let us focus on one project for the moment—the space station. I listened to the President the other day. I traditionally have voted against the space station without the proper scientific knowledge for doing so, based upon what I thought were inadequate defenses of it by those who supported it. And as subcommittee chairman now with the President and the Vice President both wanting it, I have decided that I have to clean my slate and start my review all over again. And I am, in fact, doing that.

Now, how does your procedure, your assessment of performance procedure help us with the space station?

Dr. GRIFFITHS. The way that the issue has been phrased in recent years is, in my opinion, flawed. It has been big science versus little science. That is what you read in the press. That is as off the mark as the linear model of innovation as applied to development and production is in capturing the research system.

This report would say that the approach is not big science versus little science, but it is by major area and field in science. And let us take, for example, space science or let us take physics. We want to be among the leaders in physics. Physics as an enterprise has all kinds of activity within it. It has individual investigators. It has large projects—that is the supercollider. It has medium-sized projects.

What we are concerned with is the national performance to be at least at the forefront in physics. And that, then, would require that within physics one look at this whole spectrum of activity, the individual, the mid-size, and the megaprojects, and consider those as a whole. And the funding of physics would be then based on our national goals for physics, whether we want to be among the leaders or in certain areas be clearly ahead, and the role of megaprojects. And individual investigators would then fall into place within that context.

Senator ROCKEFELLER. But you just take it sector by sector?

Dr. GRIFFITHS. You take it by the field.

Senator ROCKEFELLER. But how is that fair, then, when a space station presumably involves many sectors, does it not, that would have to be evaluated?

Dr. GRIFFITHS. Well, the science that is involved would primarily be space science, astronomy, areas of astronomy. So, I think that there we should ask the question from a scientific point of view. There are other points of view that come into this equation, as you know, from the point of view of science how we want to be positioned in this field.

Senator ROCKEFELLER. Phillip, I understand what you are saying but I am having trouble getting you to answer my question, and maybe you do not want to at this time. Frank, maybe you do not want to. But if you have a system for evaluating what it is that is important to us and then you get a megaproject versus lots of minor projects, sometimes if you fund a megaproject all kinds of other ones which might be important but less expensive go.

I mean, how does this system help us evaluate or come to a decision on the space station?

Dr. PRESS. The space station is a very special case. This is the way I would have done it. The primary purpose of the space station is human survival in space for the exploration of the planets. That is, we do not need the space station to do science. Unmanned spacecraft can do science very well.

A President, therefore, has to start by proposing the space station as part of a larger mission: "I want the United States, either by itself or in cooperation with other countries, to embark on a program of the human exploration of the planets. By the year 20??, humans should be on Mars."

If one has that as a national goal, agreed to by Congress, then one can work back from that goal and decide what kind of technology is needed to achieve that. The purpose of the space station is to see whether a human can survive in a zero-gravity environment, bombarded by radiation, for a long trip in space. That is the primary purpose. Working back from that goal as a country, one can arrive at the kind of space station that is needed and when it is needed. That has to be the basis of the decision.

I do recognize that the space station involves at the present time, tens of thousands of jobs. It may well be that the decision will be based on that, on the economic aspects rather than the rational procedure that I have described.

Senator ROCKEFELLER. But you cannot agree with that. You cannot agree with that as valid. That could be a factor, but let us talk about this philosophically. Space caught the imagination of this country at a time when we felt ourselves deficient in mathematics, and worried about Sputnik and the Russians. And so we set ourselves a national policy in essence to catch up with the Russians and to reaffirm our own intellectual and scientific capacity.

You know, the Russians are no longer particularly a threat. It is a very different world than it was. In domestic problems back the sixties there were race problems, as there are today. But there was none of the rest of the crunch that we think about today or that we are trying to attend to today.

Now, in essence you are saying we should look at where should we be in science, and how important is that, and what do we have to do to maintain being among the leaders in different parts of science. What you are not answering is, what if the reason for

starting up the program was wrong, perhaps right for then but wrong for now?

Because if you tell me that there is no scientific reason for the space station, and you say that we can turn Russian experience on how long can a human body under what conditions can survive, or we could do it in simpler ways that did not involve a space station, then it becomes a much less expensive proposition.

So, in essence, then, if you come to the economics of jobs, that means that if you start something you cannot stop it even though the philosophy or the reason for it may have changed.

Dr. PRESS. Well, that decision has to be part of the political process, and that is what you are wrestling right now. Whether the space station should go forward or not is not a scientific question.

Senator ROCKEFELLER. Anything in the way of crystals or anything else can be done in an unmanned?

Dr. PRESS. Yes. Materials processing in space is something that could be done. But it does not survive the market test. Very few companies are willing to pay money for that purpose. So, it is a question of human survivalability.

Senator ROCKEFELLER. So, then, human survival. Let us not look at the human survival for a moment, but the exploration of other planets in space. How does that get factored into the system that you put forward, Dr. Griffiths, regarding the exploration of space?

Dr. GRIFFITHS. Well, I think that the issues that we addressed dealt with science research and with technology development and adoption. The human exploration of space is related but is not really one of those issues.

Senator ROCKEFELLER. You do not address it, then.

Dr. GRIFFITHS. We do not address it.

Senator ROCKEFELLER. Frank, I interrupted you.

Dr. PRESS. No, that is fine.

Senator ROCKEFELLER. Well, what would you do about it.

Dr. PRESS. As a geologist, I am in favor of the scientific exploration of the other planets. I think we will learn a great deal about the origin of our own planet and its future. We will learn about our climate and how it will progress. It is intellectually exciting. It is all of that. However, most of that work can be done without a space station. It can be done by unmanned, robotic devices.

I could understand a President, a visionary President, saying that he wants this country to involve other nations and engage in a program of sending humans to other planets. Historically, it would be a rather spectacular thing. It might excite the whole Nation. It might get countries to work together in a fashion that they have never done before.

If that is the case, and you work back from there, you will need a space station. You will have to see what kind of centrifuges you will need to enable humans physiologically to survive this 2-year mission, what level of gravity. And then, of course, the radiation and the other effects of living in space.

The Russians do not have the answers. Even through their records of humans in space, they do not have these answers.

Senator ROCKEFELLER. Their data is not as exacting as we would wish?

Dr. PRESS. Yes, that is the case. There were very sick Russian cosmonauts coming off of that spacecraft after 8 months in space, and we have to understand better the reasons for that.

Senator ROCKEFELLER. You slipped very easily into saying, if we have a President, a visionary President who wants to do that, then this is a very stimulating and intellectually exciting thing. And then if you let that become a valid assumption for a moment, then we would have to start working back from that proposition.

I guess one of the things I am trying to say to you is if you are looking at a space station in which science cannot be validated in defense of the space station, and you are looking at $59 or $60 billion, whatever it is, over 20 years, are there other ways much more prosaic that you can take those same 12-, 13-, 14-year-old kids that I was talking about, and raise their hopes and excite them? Does it have to be exploration? Is that the way the world of science works in young minds now?

Dr. PRESS. What you are really asking me is, are we stuck with a space station in the present time?

Senator ROCKEFELLER. No, we are not. No, no.

Dr. PRESS. We are stuck with a making a decision on that space station at this time.

Senator ROCKEFELLER. Yes.

Dr. PRESS. What should we do about it? What I have to say is that, that is really a political decision. There is nothing I can say, as a scientist——

Senator ROCKEFELLER. Oh, yes there is. Because it is a question of expanding young minds, creating the vision and excitement, not just for young scientists, potentially good scientific and engineering minds, but also whatever else you were including when you said this excites the psyche of the Nation. Is that valid? Sufficiently valid, for $60 billion, for 20 years?

Dr. PRESS. Well, how do you feel about the Apollo Program, and the Kennedy program of putting men on the moon? Do you think that had a return to the Nation, in terms of exciting a large number of people?

Senator ROCKEFELLER. Absolutely. Absolutely.

Dr. PRESS. Well, some future President might want to do the same thing.

Senator ROCKEFELLER. But that is pretending that the 1960's and the 1990's are the same time, and they are not.

Dr. PRESS. True.

Senator ROCKEFELLER. But that is not your job, is it? Because you are looking—that is right, that is my job.

Dr. PRESS. That is right.

Senator ROCKEFELLER. OK, you have got it. Let us turn to biomedical research for a second, Frank, if you do not mind.

That sort of technology and medicine is also wonderfully stimulating, and intellectually very exciting and incredibly expensive. And I really do not know how much of the hyperinflation of medicine comes from technology. It is not just people getting older and living longer, using more medicine. So much of it does come from technology.

Now, it has almost come to the point where the cost of technology is becoming an enemy of a rational consideration of what we are

going to do in our health care. And as you know, Oregon has made some judgments about that.

Do you think we need to change the way we focus on biomedical research? And, for example, would a greater emphasis on prevention and vaccines be more useful than further refinements of MRI's, things of that sort? How do you, philosophically, deal with that?

Dr. PRESS. We are straying from our report here. I think these are all very important questions, and I know of your long-time interest in these areas. But these are subjects that our report does not touch. We cannot answer everything.

Your question, however, is very seductive, and it is hard for me to hold back. So, let me say just a few things, while pointing out that this departs from the report.

I think technology has the potential for increasing the cost of medicine, if it is poorly used; however, it can also decrease the cost of medicine, if it is used well. I think that it is overused today, to protect physicians, because of consumer demand in a system of third-party payers, and for other reasons. But to say that technology is bad, because it is pricing itself out of the market, is simplistic.

Senator ROCKEFELLER. Yes, I agree.

Dr. PRESS. We just have to find better ways to use technology, rather than simply stopping certain kinds of developments. I think the potential of technology for curing disease and making medicine cheaper, does exist; but we have not attacked that problem well. And we have to do better.

Senator ROCKEFELLER. OK. Let me just ask a really simplistic question, to both of you.

This is the so-called "King for a Day" type of question: You have $2 billion in excess defense dollars that you found, and everybody agreed that you could take that and invest it in Federal R&D programs any way that you wanted to, a couple billion, $2 or $3 billion: How would each of you do that? Where would you put it?

Dr. PRESS. When I was in the Government, President Carter said to me, "You have an extra $100 million to put into science. How would you do that?"

And what I did was write to each of the Cabinet officers and the heads of agencies, and said: "These funds are available; let us have a competition. Let me see your ideas. What would you like to spend this money on, if it were made available to you?" The proposals came in, and we made a decision based upon the excitement of the proposals and their potential contribution to improving the quality of life of Americans. We had a mix of criteria at that time. The best proposals that came in were the ones that were funded.

I think, rather than telling you right now how I would spend $2 billion, I would undertake that kind of activity and make the judgment at that time.

Senator ROCKEFELLER. That is interesting to me, that you would have asked them at all. Why would you not have sat down at your own desk?

Dr. PRESS. Because they have a lot of good scientists and engineers working in those agencies who——

Senator ROCKEFELLER. Some of them——

Dr. PRESS. Well, yes.

Senator ROCKEFELLER. Well, what, in fact, did you do——

Dr. PRESS. I did not write the Treasury Department and ask them how they would spend the science money. But I certainly wrote to the Energy Department and to NASA.

Senator ROCKEFELLER. What did you do with the $100 million?

Dr. PRESS. Well, we distributed it at that time, based upon the best proposals that we received. Are you asking me to recall?

Senator ROCKEFELLER. Yes, I do not want you to answer it that way.

Dr. PRESS. Well, I would have to review it. It was s 14 years ago. But that was the process that we used. And I think that is the way to answer your question.

Senator ROCKEFELLER. How would you do it, Phillip?

Dr. GRIFFITHS. It is a similar answer. I am on the National Science Board, and one of the things I am struck by is the number of opportunities which, from many different points of view, seem very compelling, that come before the National Science Foundation but that it is not able to take advantage of.

There are scientific opportunities; you know, almost every field is undergoing now a major explosion in the knowledge within the field, and especially with the coupling of knowledge between different fields, the interrelatedness, the unity of science. It is very striking.

In human resource areas, one senses that, in fact, we are beginning to make some progress on a small scale in some of the issues, very vexing issues, about science education in the lower levels, kindergarten through college. Some of the experiments are working; and one would like to scale them up, and see what more money would do, in the system.

In the infrastructure, there is certainly a sense among many in the scientific community that we are incurring a mortgage on our infrastructure, facilities and instrumentation.

All of these are the realities that any agency has to deal with when it has a budget; that it is constrained and it is going to be more constrained. But as Frank suggested, I think, I do not know the answer off the top of my head, but certainly among the things that I have seen coming forward as a member of the Science Board, I think it could be a very lively competition.

Senator ROCKEFELLER. How come neither of you has further mentioned, during the course of the morning, critical technologies? And, in answer to that last question?

Dr. GRIFFITHS. I was answering it. I will speak first for myself, sort of reflecting on the one Federal agency that I know does have a board like the National Science Board, that approves its budget. And critical technologies do not fall strictly within the purview of NSF. It does things with——

Senator ROCKEFELLER. So what? We are talking large scale here. I mean, I guess I am asking you——

Dr. PRESS. Critical technologies are extremely important. In one recent survey, the Department of Commerce by polling experts from across the country by industry, identified a dozen areas of critical technology. They found that these critical technologies,

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which are not yet on the market, will be responsible for a trillion dollars of new business globally by the end of the decade.

They have a very, very important role. We as a nation have to learn how to identify them, and do what we can through the Federal Government. But primarily this is an industrial responsibility of making sure that we perform well in all of these critical technologies, and not only in high-technology industries. These are technologies that will diffuse throughout the whole industrial sector—low-technology, middle-technology, and high-technology—and improve productivity; and improve competitive position.

There is no question in my mind about the importance of critical technologies, and that the Government has to find an appropriate role. In this report we have described the different ways that the Government can participate in these globally important technologies.

Senator ROCKEFELLER. One final question. It used to be, and I want to know if it still is the case, that when industries faced economic down cycles, the first thing they cut was research and development. And maybe that was not true for all of them, but it seemed to be for so many of them.

We have seen now, over the last year, really stunning downsizing by corporations. Frightening. I mean, on the one hand, Sears, which I assume does not do much research and development; and on the other hand, IBM and Xerox and others, which do. We have also seen, as you indicated, new consortiums, in batteries, new efforts on a flexible fuel vehicles, Sematech and things like that.

But as corporations are now downsizing, which they all appear to be doing and which seems like inevitable for all of them, has that approach, about cutting the research and development, gone? Has that changed at all? Much more reluctance to cut it? Or is it still one of the first things that goes?

Dr. PRESS. There are two aspects to cutting R&D costs. One, simply to maximize the profits in the near term which goes on to corporate buyouts, and we have seen that. The other aspect involves looking at the productivity of the R&D program, to see whether it is paying off or whether it has been wasteful. I can understand reducing costs where not much has come out of the R&D program. I cannot support cutting costs for near-term profits; I think that is a mistake.

Senator ROCKEFELLER. I know. I agree with you on what you are saying. But what is happening, as you have observed it in corporate life?

Dr. PRESS. I think those companies with managers with a vision of the future, who know where the world is going in terms of science and technology, who understand what they have to do to remain competitive, and who understand that the comparative advantage of the United States depends on a strong science and technology base, are not cutting.

There are other companies which are cashing in their future; they are mortgaging their future by these kinds of cuts.

Senator ROCKEFELLER. I thank you both very much.

[Whereupon, at 12:34 p.m., the hearing was adjourned.]

["Science, Technology, and the Federal Government," by the Committee on Science, Engineering, and Public Policy; the Na-

tional Academy of Sciences; the National Academy of Engineering; and the Institute of Medicine may be found in the committee's files.]

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